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Terrero et al.

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(54) MEDIA HEIGHT DETECTION SYSTEM FOR A PRINTING APPARATUS

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(51) **Int. Cl.**

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B41J 25/308	(2006.01)
B41J 29/393	(2006.01)
B41J 2/01	(2006.01)
B41J 11/00	(2006.01)

(52) **U.S. Cl.**

CPC ***B41J 11/0005*** (2013.01); ***B41J 11/0095*** (2013.01)

(58) **Field of Classification Search**

CPC B41J 29/393; B41J 25/308; B41J 11/0095; B41J 29/38; B41J 11/42; B41J 11/0005

USPC 347/8, 14, 16, 19, 37, 101, 104

See application file for complete search history.

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* cited by examiner

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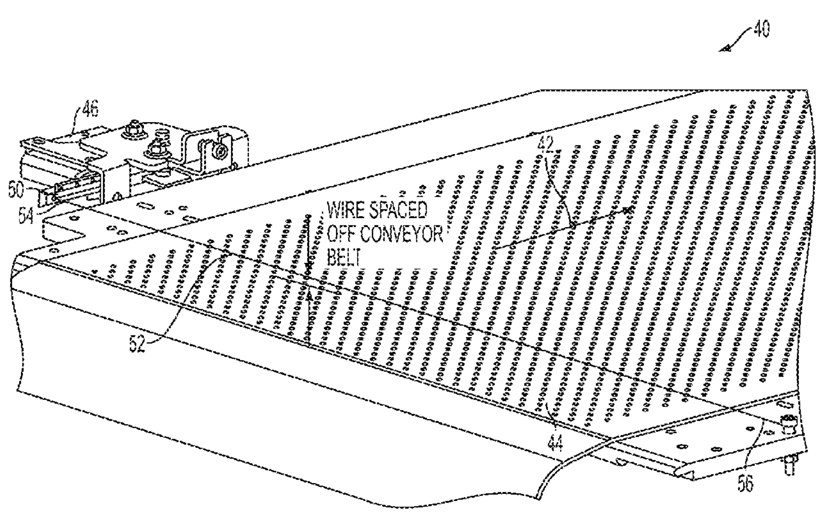
(57) **ABSTRACT**

A media height detection system is used in connection with an inkjet printer. A filament is disposed above the process path and transverse to the process direction. A displacement sensor mounted adjacent the process path has a connecting member extending outward. The filament is attached to the connecting member and anchored to the printer. A transducer in the displacement sensor generates an electrical signal in response to a force on the filament. The filament contacts the lead edge of the sheet in the event of sheet curl in excess of a predetermined curl range. This will cause the force in the filament, which is conveyed to the displacement sensor to generate the signal. The print head can be elevated in response to the signal, so that the sheet does not impact the print heads, causing damage. Alternately, the sheet can be discarded.

7 Claims, 7 Drawing Sheets



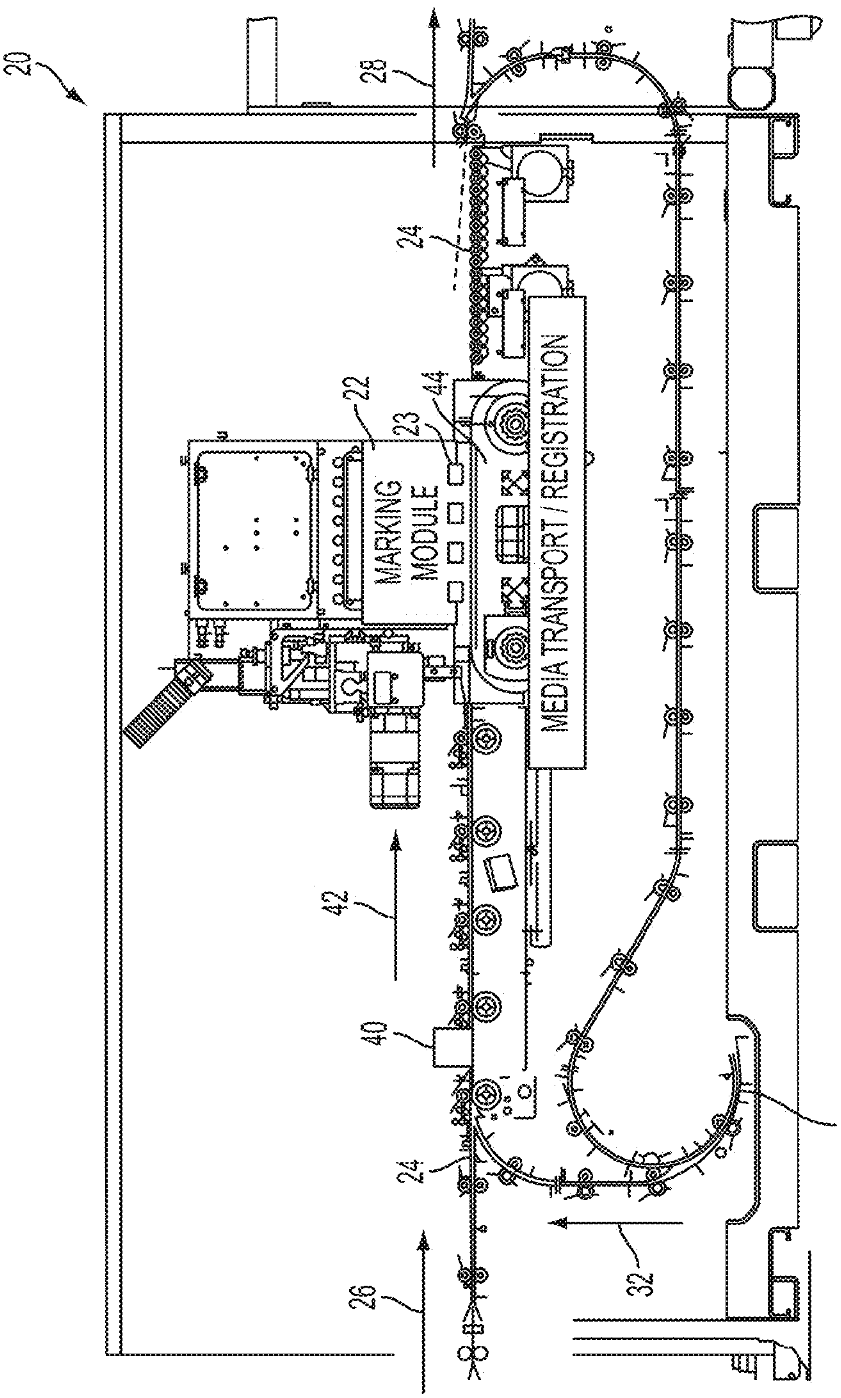

20
28
24
22
23
44
MARKING MODULE
MEDIA TRANSPORT / REGISTRATION
42
40
24
30
32
26

FIG. 1

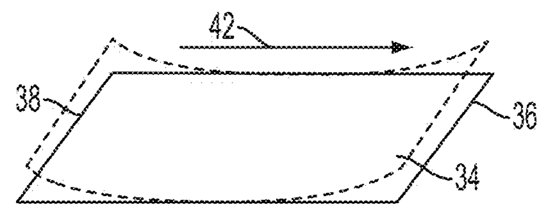


FIG. 2

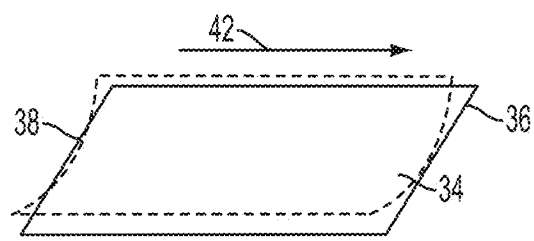


FIG. 3

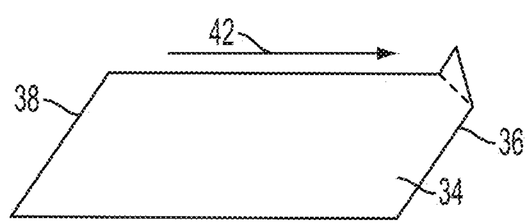


FIG. 4

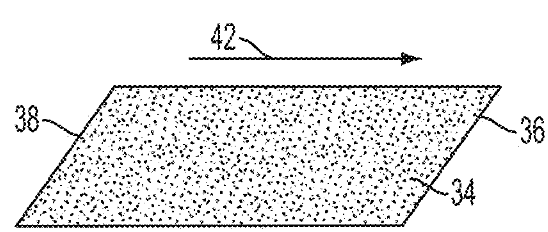


FIG. 5

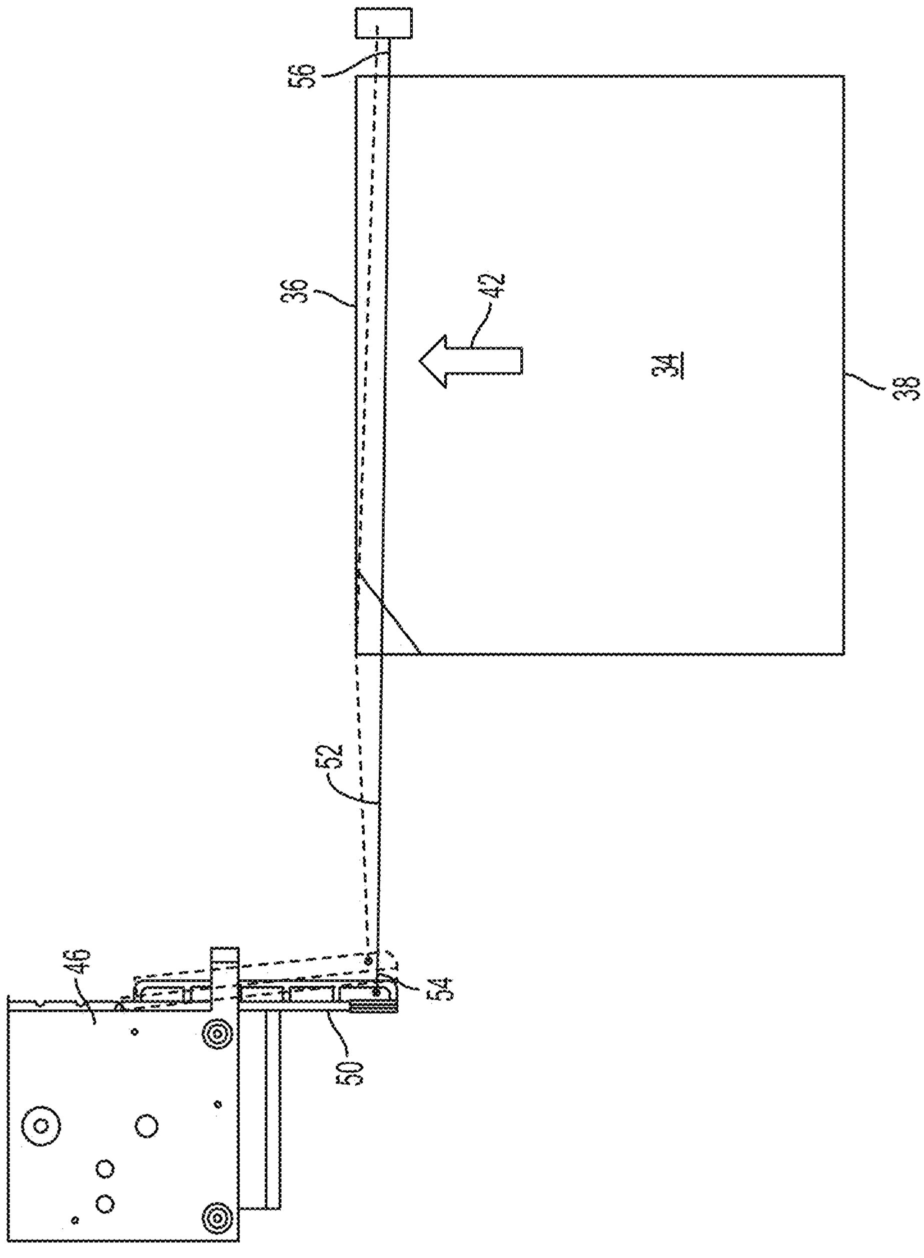


FIG. 6

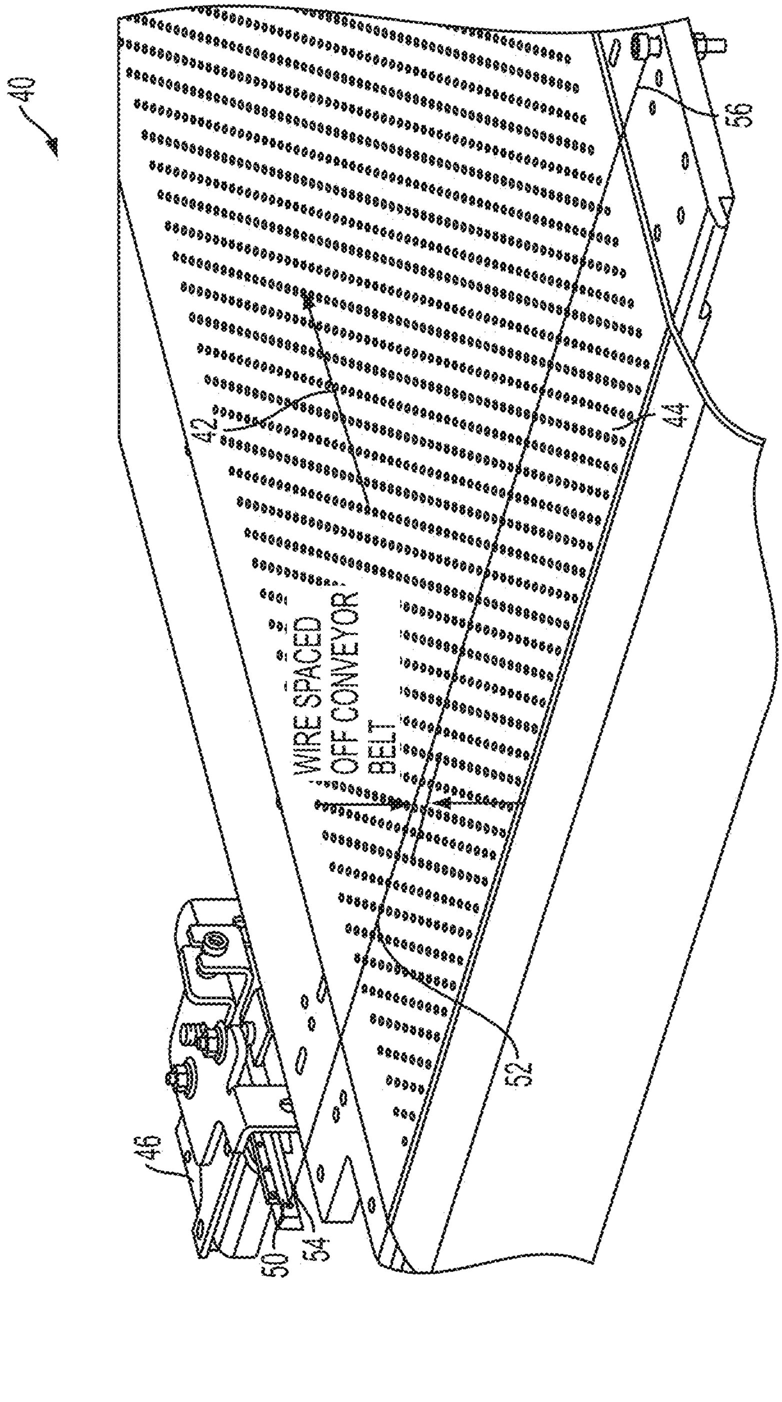


FIG. 7

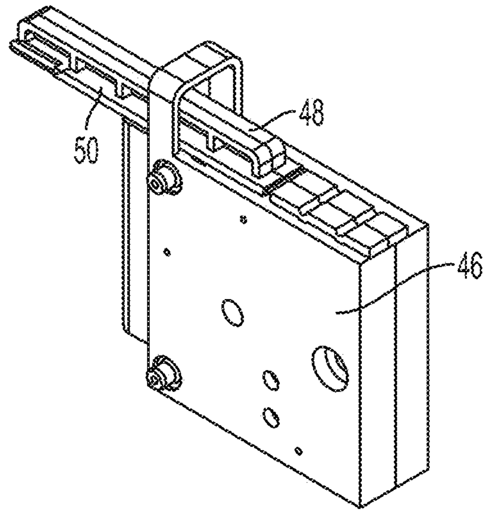


FIG. 8

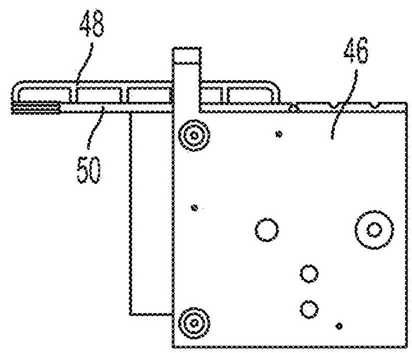


FIG. 9

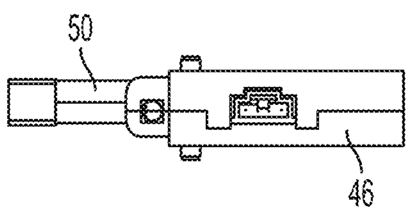


FIG. 10

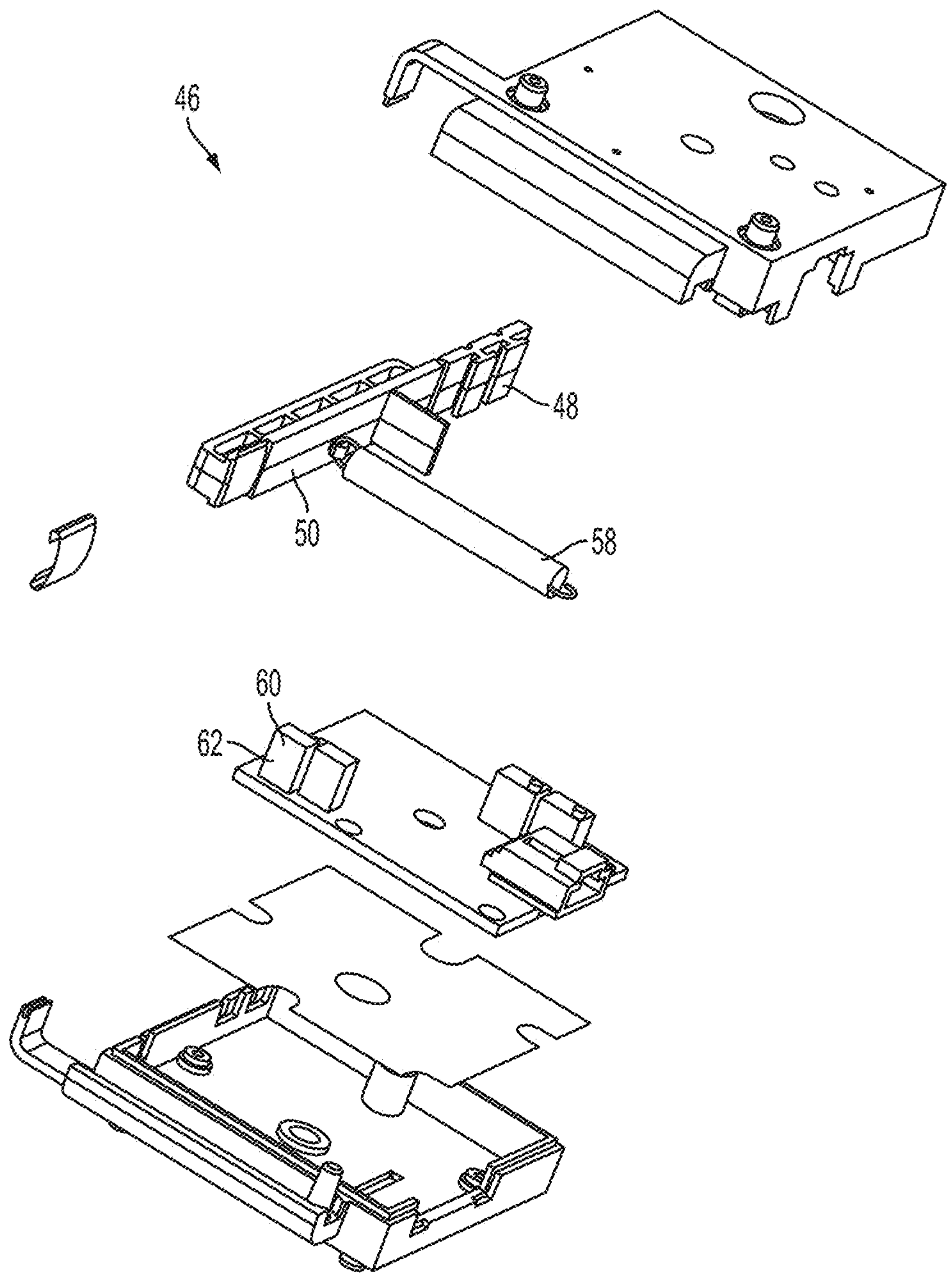


FIG. 11

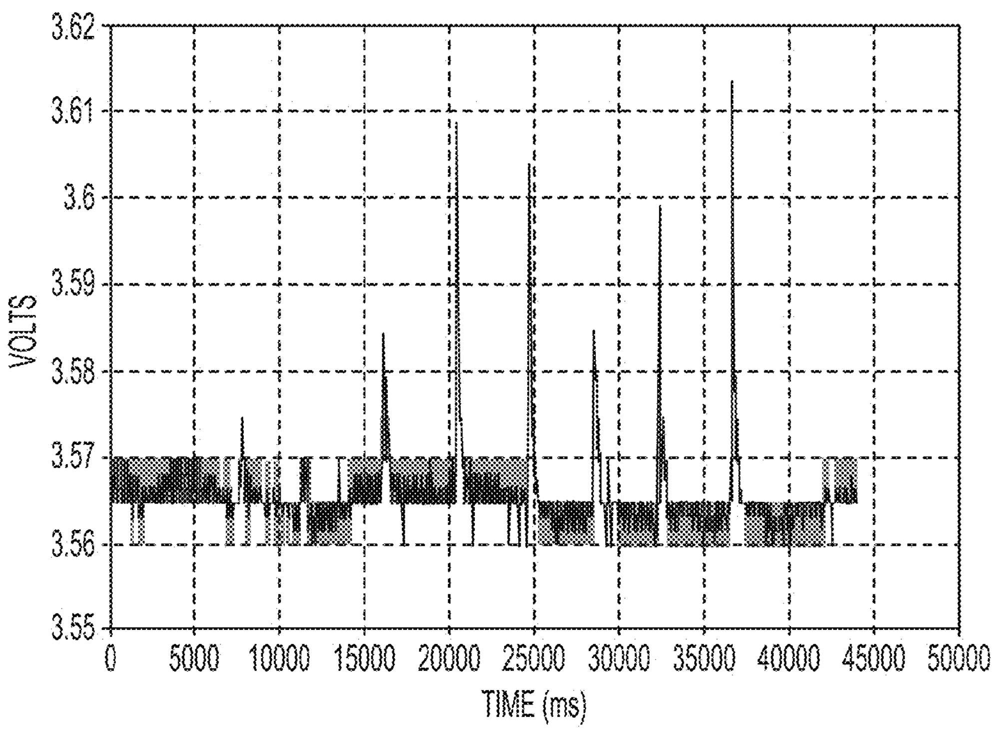

3.62
3.61
3.6
3.59
3.58
3.57
3.56
3.55
VOLTS
0
5000
10000
15000
20000
25000
30000
35000
40000
45000
50000
TIME (ms)

FIG. 12

MEDIA HEIGHT DETECTION SYSTEM FOR A PRINTING APPARATUS

INCORPORATION BY REFERENCE

Not applicable.

TECHNICAL FIELD

This invention relates to inkjet digital printing machines, and, more particularly, to an apparatus, system, and method for detecting excessive media height for protecting the printing head from damage by impaction of media sheets in an inkjet digital printing machine.

BACKGROUND

Digital printing machines can take on a variety of configurations. One common process is that of electrostatographic printing, which is carried out by exposing a light image of an original document to a uniformly charged photoreceptive member to discharge selected areas. A charged developing material is deposited to develop a visible image. The developing material is transferred to a medium sheet (paper) and heat fixed.

Another common process is that of direct to paper ink jet printing systems. In ink jet printing, tiny droplets of ink are sprayed onto the paper in a controlled manner to form the image. Other processes are well known to those skilled in the art. The primary output product for a typical digital printing system is a printed copy substrate such as a sheet of paper bearing printed information in a specified format. More development is underway of production printers that require inkjet direct marking onto cut sheet media. This includes UV gel inks, solid inks and aqueous inks.

The output sheet can be printed on one side only, known as simplex, or on both sides of the sheet, known as duplex printing. In order to duplex print, the sheet is fed through a marking engine to print on the first side, then the sheet is inverted and fed through the marking engine a second time to print on the reverse side. The apparatus that turns the sheet over is called an inverter.

FIG. **1** shows a state-of-the-art inkjet digital printing machine **20**. Printer **20** includes a marking module or engine **22** having a plurality of ink jet print heads **23**, disposed centrally on the marking engine **22**, and facing downward. Printer **20** has a media path **24** along which the media sheet **34** moves. Printer **20** has a media path entrance **26** where sheets are fed into the printer by a media sheet feeder (not shown). Printer **20** also has a media path exit **28** where sheets leave the printer and are fed into a finisher (not shown). Printer **20** has an inverter **30** to turn the sheet over for duplex printing. A media sheet **34** leaving the inverter **30** follows arrow **32** back to the marking engine **22** for printing on the reverse side. Arrows **26** and **28** also indicate the process path direction, which is downstream from entrance **26** toward exit **28**.

In cut sheet printing devices, under certain conditions, the lead-edge of the paper can curl up and have potential for separating from the marking transport and contact the print head. A sheet with out-of-spec flatness can occur when a duplexed sheet has a heavy ink image on the trail edge of side **1**, which then becomes the lead edge when inverted and curls towards Side **2**. This is most severe when the paper is thin, and the cross-process direction image is parallel to the grain direction of the paper (Example: letter size paper, grain-long, long-edge-feed).

In direct-to-paper ink jet marking engines, an ink jet print head is mounted such that the face (where the ink nozzles are located) is mounted a fixed distance from the surface of the media. The gap is typically 1 mm or less. Because the paper curl height can be several millimeters, it poses a risk to the print head because it can hit the print head face plate when it passes through the nominally thin gap that the print heads are spaced from the media.

Media sheets, typically paper, can curl or distort in several ways. LE curl is a concave upward bending along the process direction, such that the lead edge (LE) and the trail edge (TE) rise up off the transport, as shown in FIG. **2**. The raised LE can impact multiple print heads across the paper width. Cross curl is a concave upward bending across the process direction, such that the left side and right side edges rise up off the transport, as shown in FIG. **3**. The raised sides can impact multiple print heads. Both LE curl and cross curl are caused by ink on the first side of a duplex print that is inverted.

Dog ear is a crease with upward bending across the process direction at an angle across a corner, as shown in FIG. **4**. The crease can impact multiple print heads downstream. This is caused by sheet damage in the paper path. Print head damage is severe due to greater pressure.

Cockle is multiple bumps or peaks distributed throughout the sheet. The bumps can impact multiple print heads downstream. Cockle is caused by the drying rate of ink, especially aqueous based inks.

The print head gap or distance of the print head to the sheet must be within 1 mm. The media sheet must pass freely under the print heads. The sheet must not contact the face of the print head, or serious damage will result. This requirement poses a challenge for cut sheet media since the corners, edges and body of the sheet may not be completely flat. The use of a hold down transport such as a vacuum conveyor helps to maintain the sheet flat and within the gap for the most part. Purposely delivering sheets with downward curl from the sheet supply tray also helps to hold the sheet flat. Nevertheless it is not guaranteed that a sheet is flat over the entire surface.

Ink jet print heads are very delicate and can easily be damaged if the face of the print head is contacted by the media which is passing nearby. The print heads are also very expensive and thus, it is very important to minimize any risk of damaging these print heads.

Accordingly, there is a need to provide a system, for use with inkjet printers, for detecting excessive media height due to sheet curl so that remedial action can be taken to prevent print head damage.

There is a further need to provide a media height detection system of the type described and that will match the high production rate of a digital printing machine.

There is a yet further need to provide a media height detection system of the type described and that is mechanically simple and robust, thereby minimizing cost.

SUMMARY

In one aspect, a media height detection system is for use in connection with a printer having a print head. The print head is adapted for elevating. A media sheet has a lead edge and a trail edge, and moves in a process direction along a process path. The media height detection system comprises a displacement sensor mounted adjacent the process path. The displacement sensor is adapted to generate a signal in response to a force applied to the sensor.

A filament is disposed a predetermined distance above the process path and transverse to the process direction. The filament extends between a first end attached to the displace-

ment sensor and a second end anchored to the printer. The filament is adapted for contacting the lead edge of the sheet in the event of sheet curl in excess of a predetermined curl range. This will cause the force in the filament. The force is conveyed to the displacement sensor to generate the signal in response to the filament contacting the sheet.

In another aspect, a media height detection system is for use in connection with a printer having a print head. The print head is adapted for elevating. A media sheet has a lead edge and a trail edge, and moves in a process direction along a process path. The media height detection system comprises a displacement sensor mounted adjacent the process path. The displacement sensor has a connecting member extending outward from the sensor. The displacement sensor has a transducer adapted for generating an electrical signal in response to a force on the connecting member.

A filament is disposed a predetermined distance above the process path and transverse to the process direction. The filament extends between a first end attached to the connecting member and a second end anchored to the printer. The filament is adapted for contacting the lead edge of the sheet in the event of sheet curl in excess of a predetermined curl range. This will cause the force in the filament. The force is conveyed to the displacement sensor to generate the signal in response to the filament contacting the sheet.

In yet another aspect, a method for detecting the height of a media sheet is for use in connection with a printer having a print head. The print head is adapted for elevating. A media sheet has a lead edge and a trail edge, and moves in a process direction along a process path. The method comprises mounting a displacement sensor including a transducer adjacent the process path. A connecting member extends outward from the displacement sensor. A filament is disposed a predetermined distance above the process path and transverse to the process direction. A first end of the filament is attached to the connecting member. A second end of the filament is anchored to the printer.

The filament is contacted with the lead edge of the sheet in the event of sheet curl in excess of a predetermined curl range. This causes a force in the filament by contacting the sheet. The force is conveyed to the connecting member. An electrical signal is generated with the transducer in response to the force on the connecting member.

These and other aspects, objectives, features, and advantages of the disclosed technologies will become apparent from the following detailed description of illustrative embodiments thereof, which is to be read in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic side elevational, sectional view of an exemplary production printer showing the position of a media height detection system constructed in accordance with the invention.

FIG. **2** is a schematic isometric view of a media sheet showing LE curl.

FIG. **3** is a schematic isometric view of a media sheet showing cross curl.

FIG. **4** is a schematic isometric view of a media sheet showing dog ear.

FIG. **5** is a schematic isometric view of a media sheet showing cockle.

FIG. **6** is a schematic top plan view of the media height detection system of FIG. **1** with an incoming media sheet.

FIG. **7** is a perspective view of the media height detection system of FIG. **1**.

FIG. **8** is a perspective view of a sensor used with the media height detection system of FIG. **1**.

FIG. **9** is a top plan view of the sensor of FIG. **7**.

FIG. **10** is a front elevational view of the sensor of FIG. **7**.

FIG. **11** is a perspective, exploded assembly view of the sensor of FIG. **7**.

FIG. **12** is a graph of sensor voltage vs time, for sheets impacting the wire.

It should be noted that the drawings herein are not to scale.

DETAILED DESCRIPTION

Describing now in further detail these exemplary embodiments with reference to the Figures as described above, the media height detection system is typically used in a select location or locations of the paper path or paths of various conventional media handling assemblies. Thus, only a portion of an exemplary media handling assembly path is illustrated herein.

As used herein, a “printer,” “printing assembly” or “printing system” refers to one or more devices used to generate “printouts” or a print outputting function, which refers to the reproduction of information on “substrate media” or “media substrate” or “media sheet” for any purpose. A “printer,” “printing assembly” or “printing system” as used herein encompasses any apparatus, such as a digital copier, bookmaking machine, facsimile machine, multi-function machine, etc. which performs a print outputting function.

A printer, printing assembly or printing system can use an “electrostatographic process” to generate printouts, which refers to forming and using electrostatic charged patterns to record and reproduce information, a “xerographic process”, which refers to the use of a resinous powder on an electrically charged plate to record and reproduce information, or other suitable processes for generating printouts, such as an ink jet process, a liquid ink process, a solid ink process, and the like. Also, such a printing system can print and/or handle either monochrome or color image data.

As used herein, “media substrate” or “media sheet” refers to, for example, paper, transparencies, parchment, film, fabric, plastic, photo-finishing papers or other coated or non-coated substrates on which information can be reproduced, preferably in the form of a sheet or web. While specific reference herein is made to a sheet or paper, it should be understood that any media substrate in the form of a sheet amounts to a reasonable equivalent thereto. Also, the “leading edge” or “lead edge” (LE) of a media substrate refers to an edge of the sheet that is furthest downstream in the process direction.

As used herein, a “media handling assembly” refers to one or more devices used for handling and/or transporting media substrate, including feeding, printing, finishing, registration and transport systems.

As used herein, the terms “process” and “process direction” refer to a procedure of moving, transporting and/or handling a substrate media sheet. The process direction is a flow path the sheet moves in during the process.

Referring to the drawing FIGS. **1-12**, a media height detection system **40** is for use in connection with a printer, especially an inkjet printer **20** having an inkjet print head, and typically, a plurality of inkjet print heads **23**. The print heads **23** are located on a marking module or engine **22**, adapted for elevating, or being selectively raised above the transport **44**. A media sheet **34** has a lead edge **36** and a trail edge **38**. The media sheet **34** moves in a process direction (from left to right in FIG. **1**) shown by arrow **42**, along a process path **24** on a sheet transport **44**, such as a vacuum transport. The media height detection system **40** comprises a displacement sensor **46** mounted adjacent the process path **24**. The displacement sensor **46** has a connecting member **48** extending outward from the sensor **46**. The connecting member **48** includes an arm **50** extending upstream.

A filament **52** is disposed a predetermined distance above the process path **24** and transverse to the process direction **42**. The filament **52** extends between a first end **54** attached to the connecting member **48** and a second end **56** anchored to the printer **20**. The filament **52** is positioned to contact the lead edge **36** of the sheet **34** in the event of sheet curl in excess of a predetermined curl range. This will cause the force in the filament **52**. The force is conveyed to the displacement sensor **46** to generate the signal in response to the filament **52** contacting the sheet **34**.

In the embodiment shown, the connecting member arm **50** extends upstream or counter to the process direction. It is to be understood that the connecting member **48** can extend in any direction, and that any direction will be considered equivalent within the spirit and scope of the claims. The arm **50** is attached transversely to the filament **52**. The arm **50** is able to flex in response to the force. A spring **58** is attached to the arm **50** so as to tension the filament **52**.

The displacement sensor **46** has a transducer **60** adapted for generating an electrical signal in response to a force on the connecting member **48**. The signal is proportional to the force applied. The transducer **52** includes a photoreceptor **62**, or similar photo-optical device. Alternatively, the transducer **52** can include a piezoelectric crystal, a capacitive or inductive device, or an electromagnetic device. In the embodiment shown, the photoreceptor **62** generates the electrical signal in response to the arm flexing.

The filament predetermined distance above the process path is the predetermined curl range, preferably within the range of 0.50 mm to 1.0 mm. Optionally, the range can be 0.40mm to 2.0 mm, or 0.30mm to 3.0 mm.

The filament **52** is made from a material capable of carrying a tensile load. The material, for example, can be selected from the group consisting of: metal wire; polymeric resin; carbon graphite; and plant fiber. It is to be understood that alternative materials will be considered equivalent within the spirit and scope of the claims.

Mitigation of print head damage is carried out in response to the signal. The mitigating means typically will include one of two procedures. The print head **23** can be elevated in response to the signal. The curled sheet **34** then passes below the raised print head **23**, while receiving additional printing. The print head drawer, which is mounted on vertical slides, could be raised slightly (perhaps as much as 5 mm) to allow the out-of-spec paper to pass through without contacting the print head. Alternatively, the media sheet **34** can be directed away from the process path **24** in response to the signal. The media sheet **34** is then moved to a tray (not shown) for waste.

A method for detecting the height of a media sheet is for use in connection with a printer, and especially an inkjet printer **20** having an inkjet print head **23**. The print head **23** is adapted for elevating. A media sheet **34** has a lead edge **36** and a trail edge **38**, and moves in a process direction **42** along a process path **24**. The method comprises mounting a displacement sensor **46** including a transducer **60** adjacent the process path **24**. A connecting member **48** extends outward from the displacement sensor **46**. A filament **52** is disposed a predetermined distance above the process path **24** and transverse to the process direction **42**. A first end **54** of the filament **52** is attached to the connecting member **48**. A second end **56** of the filament **52** is anchored to the printer **20**.

The filament **52** is contacted with the lead edge **36** of the sheet **34** in the event of sheet curl in excess of a predetermined curl range. This causes a force in the filament **52** by contacting the sheet **34**. The force is conveyed to the connecting member **48**. An electrical signal is generated with the transducer **60** in response to the force on the connecting member **48**.

An arm **50** of the connecting member **48** is attached transversely to the filament **52**. The filament **52** is tensioned by attaching a spring **58** to the arm **50**. The arm **50** flexes in response to the force. A photoreceptor **62** is included in the transducer **60**. An electrical signal is generated with the photoreceptor **62** in response to the arm **50** flexing.

The filament **52** is disposed above the process path a distance within the range of 0.50 mm to 1.0 mm. Alternative distances range from 0.40 mm to 2.0 mm and from 0.30 mm to 3.0 mm.

The print head **23** can be elevated in response to the signal. Alternatively, the media sheet **34** can be directed away from the process path **24** in response to the signal.

It will be appreciated that variants of the above-disclosed and other features and functions, or alternatives thereof, may be desirably combined into many other different systems or applications. Various presently unforeseen or unanticipated alternatives, modifications, variations, or improvements therein may be subsequently made by those skilled in the art which are also intended to be encompassed by the following claims.

What is claimed is:

1. A media height detection system for use in connection with a printer having a print head, the print head being adapted for elevating, and a media sheet having a lead edge and a trail edge, the media sheet moving in a process direction along a process path, the media height detection system comprising:

a displacement sensor mounted adjacent the process path, the displacement sensor being adapted to generate a signal in response to a force applied to the sensor;

a filament disposed a predetermined distance above the process path and transverse to the process direction, the filament extending between a first end attached to the displacement sensor and a second end anchored to the printer, the filament being adapted for contacting the lead edge of the sheet in the event of sheet curl in excess of a predetermined curl range, so as to cause the force in the filament, and to convey the force to the displacement sensor to generate the signal in response to the filament contacting the sheet;

wherein the printer is an inkjet printer having an inkjet print head, wherein the displacement sensor further comprises the media height detection system further comprising:

a connecting member extending outward from the sensor, the filament being attached to the connecting member to convey the force to the connecting member;

wherein the displacement sensor further comprises a transducer adapted to respond to the force on the connecting member, the transducer being adapted for generating the signal proportional to the force; and

wherein the signal is an electrical signal; and

wherein the displacement sensor further comprises:

the connecting member includes an arm attached transversely to the filament, the arm being adapted for flexing in response to the force;

a spring attached to the arm so as to tension the filament; and the transducer includes a photoreceptor adapted to respond to the arm flexing.

2. The media height detection system of claim 1, wherein the print head is adapted to be elevated in response to the signal.

3. The media height detection system of claim 1, wherein the media sheet is adapted to be directed away from the process path in response to the signal.

4. The media height detection system of claim 1, wherein the filament predetermined distance above the process path is within the range of 0.50 mm to 1.0 mm.

5. The media height detection system of claim 1, wherein the filament predetermined distance above the process path is within the range of 0.40 mm to 2.0 mm.

6. The media height detection system of claim 1, wherein the filament predetermined distance above the process path is within the range of 0.30 mm to 3.0 mm.

7. The media height detection system of claim 1, wherein the filament comprises a material adapted to carry a tensile load selected from the group consisting of:

metal wire;
polymeric resin;
carbon graphite;
glass fiber; and
plant fiber.

* * * * *